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LONG-TERM POTENTIAL FOR IMPRINTING IN DUCKS AND CHICKENS

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In the first of five experiments, three of four adult ducks who had been reared in visual isolation gradually developed strong approach responses towards a moving panel of colored lights. Experiment 2 provided evidence that the ducks' approach response reflected the same sort of social attachment that is typically formed to moving objects by newly hatched ducklings. Experiment 3 revealed that the fourth duck would not approach the moving stimulus even after additional exposure to it, but would approach a conspecific after group housing had been enforced for seven days. In Experiment 4, none of five adult chickens who had been reared in visual isolation developed approach responses towards the moving stimulus, even though in Experiment 5, newly hatched chicks approached the stimulus quite readily. Taken together, these findings (a) indicate that ducks retain the ability to form filial-type attachments to novel objects throughout their lives, and (b) offer preliminary evidence that chickens do not retain this ability into adulthood.

Key words: imprinting, critical period, species differences, ducks, chickens

The concept of a "critical" or "sensitive" period—i.e., an early developmental period after which new social attachments are formed with difficulty if at all—has a long and interesting history in the study of filial imprinting in precocial birds. The apparent existence of such a period achieved great prominence in the early writings of both Lorenz (1935, 1937) and Hess (1959a, b), although the phenomenon was discussed by earlier investigators of imprinting as well (e.g., James, 1890; Morgan, 1896; Spalding, 1873). But while many studies have found a marked decrease in initial filial responsiveness over the first day or two posthatch (Bjarvall, 1968; Hess & Schaefer, 1959; Jaynes, 1957; Ramsay & Hess, 1954; Weidmann, 1958), other work has indicated that the length of this period is not fixed for a given species but instead depends on rearing conditions, the nature of the imprinting object, the measures of filial behavior that are employed, and perhaps even on how the period itself is measured (Baer & Gray, 1960; Case & Graves, 1978; Gottlieb, 1961, 1963; McDonald, 1968; Moltz & Stettner, 1961; Williams, 1972).

I would like to thank Karen S. Holopigian and Ann L. Maliniak for their help in conducting these experiments. Reprint requests should be sent to Leonard A. Eiserer, Whitely Psychology Laboratories, Franklin and Marshall College, P.O. Box 3003, Lancaster, Pennsylvania 17604.

Moreover, a substantial body of literature indicates that imprinting is still quite possible after the first few days posthatch, especially if subjects are given prolonged exposure to the imprinting object. Andrew (1966) documented following responses to a novel moving object in chicks that had been isolated during the first eight days of life; Bateson (1964) found that chicks approached a moving object after three days of posthatch isolation, albeit only after initially emitting avoidance responses; Guiton (1959) observed model-following responses in chicks that had been isolated 4 to 5 days after hatching; Boyd and Fabricius (1965) reported that although the incidence of following a novel object declined steadily with age, 17% of mallard ducklings would still follow the object even after 10 days of prior isolation; Brown (1975) found no decrement in filial responsiveness in Peking ducklings up to 5 days of age; Case and Graves (1978) reported that initial responsiveness to an imprinting object remained high in chicks who were isolated as much as 5 to 7 days posthatch; Asdourian (1967) found that ducklings who were isolated for 11 days posthatch still exhibited following behavior toward a novel moving object; and numerous studies by Hoffman and his co-workers have demonstrated the development of filial behavior toward novel moving stimuli in ducklings who have been

isolated for the first 3 to 10 days posthatch (Eiserer, 1978b; Gaioni, Hoffman, DePaulo, & Stratton, 1978; Hoffman, Ratner, & Eiserer, 1972; Hoffman, Ratner, Eiserer, & Grossman, 1974; Ratner, 1976).

In view of findings such as these, Bateson (1969) has favored the term "sensitive period" over the alternative of "critical period" because the latter implies an all-or-nothing effect while the former admits that postperiod imprinting is merely difficult, not impossible. Other authors (Fabricius, 1964) prefer to retain both terms for slightly different meanings. Still others (Ratner & Hoffman, 1974) have stressed that the concept of an all-or-nothing critical period may be completely applicable for imprinting occurring under natural conditions wherein initial escape from a novel stimulus is possible, but not in laboratory studies where escape is precluded. It appears, then, that Immelmann (1972) was quite right in concluding that the terms "critical period" and "sensitive period" are neither uniformly employed nor precisely defined throughout the literature on imprinting.

The empirical problem remains, however, of determining just how long after hatching precocial birds may be isolated and still retain the ability to form imprinting attachments to novel objects. None of the work cited above carried the period of posthatch isolation longer than a few weeks. The question thus arises as to whether precocial birds always retain the potential to imprint, or whether instead they eventually reach an age where imprinting—at least imprinting as it occurs in younger birds —is truly precluded. The first three studies in the present series sought to answer this question for ducks; the last two studies examined chickens. Together, these two groups of avians have probably been involved in about 90% of all the experimental work done on filial imprinting.

We begin by emphasizing that the present work was designed to investigate the "inherent" characteristics of imprinting rather than imprinting as it occurs naturally (see Eiserer, 1978a). Other authors have suggested that an important factor in the occurrence of imprinting after the sensitive period is whether the imprinting object is a natural stimulus or an artificial stimulus without biological significance (Case & Graves, 1978). However, since the present work sought to determine whether the imprinting that characterizes newly hatched birds can also occur in adults, and since an outstanding property of imprinting in newly hatched birds is the great effectiveness of completely unnatural objects, an artificial rather than natural stimulus was employed here.

EXPERIMENT 1

Method

Subjects

Four male Khaki Campbell ducks (*Anas platyrhynchos*), hatched in visual isolation from eggs obtained from George F. Shaw, Inc., West Chester, Pennsylvania, served. Approximately 12 hr after hatching, each bird was transferred from the incubator to an individual housing unit consisting of a brown cardboard box (53 by 91 by 79 cm) that was partially filled with bedding material. Under these circumstances the subjects could hear each other but their visual environment was restricted to the inside of their housing units. While in these units, the ducks had continuous access to food and water.

Apparatus

The experimental apparatus consisted of a plywood box (178 by 66 by 78 cm) divided by a fine-mesh stainless steel screen into two compartments, one for the duck (142 by 66 by 78 cm) and the other for the imprinting object (36 by 66 by 78 cm). The imprinting object consisted of three circular lights (one red, one green, and the third blue) mounted vertically on a wooden panel that moved horizontally along the length of the stimulus compartment (i.e., 66 cm). These lights were each 1.2 cm in diameter and spaced some 2.5 cm apart from each other. Presentations of the *moving stimulus* were produced by illuminating the three colored lights and moving the wooden panel back and forth across the otherwise darkened stimulus compartment at approximately 5.3 cm/sec. Under conditions of complete *stimulus withdrawal,* the colored lights were not illuminated and the wooden panel was not moved.

To permit assessment of the ducks' locomotor behavior during testing, the carpeted subject compartment was divided into two unequal portions by a strip of adhesive tape run-

ning across the floor, parallel to and at a distance of 28 cm from the fine-mesh screen of the stimulus compartment. Hence, the resulting small and large areas of the subject compartment were 28 by 66 cm and 114 by 66 cm, respectively, with the smaller area (the approach area) nearest the stimulus compartment. A second section of fine-mesh screen (i.e., in addition to the screen that separated the subject and stimulus compartments) was built into one of the side walls of the subject compartment. This screen (35.6 cm high by 80.0 cm long) permitted the experimenter to observe the exact location of a duck while it was in the imprinting apparatus.

Lighting in the subject compartment was provided by two continuously illuminated 7.5-W incandescent lamps mounted along the top of the compartment. These lamps were positioned so that unless the imprinting stimulus lights were also illuminated, the light that reflected from the fine-mesh screen prevented the subject from seeing into the darkened stimulus compartment. The same principle operated to prevent subjects from seeing the human observer as well.

Procedure

Imprinting procedures were begun when the ducks were 5 months old (posthatch), an age by which many females of this highly domesticated species have begun laying eggs. All ducks received a total of nine 30-min exposure sessions with the moving stimulus at the rate of two sessions per day (intersession interval within a given day was approximately 2.5 hr). Immediately following each of the sessions as well as immediately before the very first session, each duck received an approach test with the moving stimulus.

During the approach tests the imprinting stimulus remained withdrawn for 120 sec, then it was presented for 120 sec, then withdrawn for another 120 sec, and finally presented again for 120 sec. In order to ensure that the duck had to make an active response to accumulate time in the approach area, the experimenter placed the bird near the center of the subject compartment at the beginning of each of the above four 120-sec intervals.

The experimenter monitored the position of the duck throughout the tests as well as during a representative sample of exposure sessions. Approach was defined as the number of seconds that the subject spent within the 28 by 66 cm area nearest the stimulus, beginning as soon as any portion of the duck's foot touched the strip of tape that bordered the area.

Results

During the first few exposure sessions, all of the ducks showed avoidance responses (vigorous withdrawal to the far end of the subject compartment) toward the moving stimulus. Such behavior gradually waned, however, as three of the ducks shifted from avoidance to approach responses. Indeed, these three ducks actually spent most of each of the later sessions in the area nearest the fine-mesh screen. The fourth subject failed to display any approach tendency toward the imprinting stimulus, even though his avoidance responses appeared to diminish across the nine exposure sessions. In other words, this duck appeared merely to become more or less "indifferent" to the presence of the imprinting stimulus.

These effects are reflected in Figure 1, which shows the approach time of each subject during each of the tests. During the first three tests, all of the ducks failed to enter the approach quadrant even as much as would be expected by chance (about 12 sec/min, since the quadrant represented 20% of the total area in the subject compartment). Eventually, however, above-chance approach tendencies developed in Ducks 1, 2, and 3. An analysis of variance (treatments-by-subjects or repeated-measures design) was conducted on the data of all four subjects and yielded a reliable effect of exposure duration on approach behavior, $F(9,27) = 3.39$, $p < .01$.

Discussion

The present results suggest that prolonged exposure to the moving stimulus led to the gradual development of a filial-type attachment with the stimulus in three of the four subjects. It is possible, however, that the observed approach response did not actually reflect the same sort of social bond that such behavior is assumed to represent with newly hatched ducklings. In other words, the adult ducks could have developed approach tendencies because of some unrelated motivational system—e.g., exploration/curiosity, or perhaps even aggression (although aggressive behavior was never observed during the experiment). Given the presumed sexual maturity of the

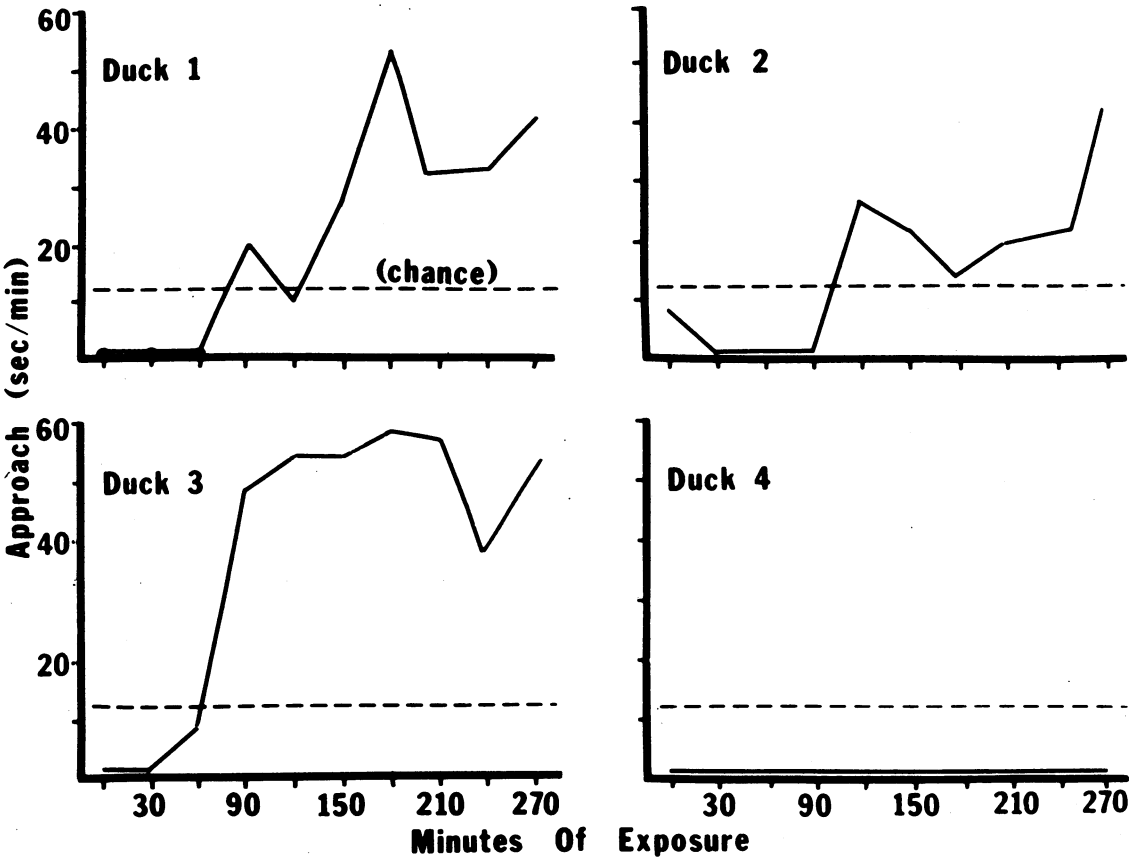

Fig. 1. Seconds (per minute) of approach to the moving stimulus by each of the adult ducks as a function of exposure duration. Note the zero-level responding of Duck 4.

subjects, the ducks' approach responses could have reflected sexual rather than filial tendencies, especially since the sensitive period for sexual imprinting is typically much later than that for filial imprinting (Gallagher, 1977; Immelmann, 1975).

Before concluding that the approach behavior seen in the present study represented a process of filial imprinting, one would want to be certain that the apparent attachment was qualitatively similar to the attachments formed by newly hatched birds. This problem was addressed in two supplementary tests (described here as Experiment 2) that were given to the three ducks who developed approach responses to the moving stimulus. The first test assessed the possibility that the adults' tendency to approach the imprinting stimulus would be enhanced in the presence of a novel, fear-inducing stimulus. Such an effect can be readily documented in newly hatched birds (Moltz, Rosenblum, & Halikas, 1959; Ratner, 1976; Sluckin & Salzen, 1961; Stettner & Tilds, 1966) and suggests that the imprinting object is a "comforting" stimulus whose presence reduces or alleviates conditions of fear or anxiety (Eiserer, 1978a).

The second supplementary test measured the amount of self-maintenance behavior (eating, preening) that occurred in the presence of the imprinting object, compared to the amount that occurred in the object's absence. Several studies with young precocial birds (Graves, 1973; Hoffman, Stratton, & Newby, 1969; Wilson, 1968) have found that self-maintenance behavior is greater in the presence than in the absence of an imprinting object—another effect which can be interpreted in terms of the comforting, anxiety-alleviating properties of the imprinting object. If the apparent attachment formed by the adult ducks in Experiment 1 was truly comparable

to the imprinting bonds that are formed by newly hatched birds, then the moving stimulus should have a facilitative effect on the self-maintenance behavior of the adults.

EXPERIMENT 2

Method

Subjects

The three adult ducks who approached the moving stimulus in Experiment 1 served.

Procedure

The first supplementary test was designed to determine whether approach to the moving stimulus would be enhanced by concurrent presentation of a novel stimulus (namely, a paper cup fastened upside down to a string, which in turn was attached to a wooden pole that was manually manipulated by the experimenter). For this test a given duck was placed in the apparatus and the imprinting stimulus remained withdrawn for an initial 120-sec period. Two types of stimulus presentation then occurred in random order, with 120-sec periods of complete stimulus withdrawal interspersed between successive presentations: either the moving stimulus was presented alone, or it was presented concurrently with the novel stimulus (to present the novel stimulus, the experimenter gently dangled the paper cup approximately 80 cm above the center of the subject compartment). Each type of stimulus presentation occurred three times within the test, and each presentation was 120-sec in duration. Care was taken to ensure that at the start of each stimulus presentation the subject was standing on the side of the subject compartment away from the stimulus compartment; thus, in order to generate an approach score, the subject had to pass directly under the area where the novel stimulus was dangling on half of the presentations. In addition, the present test employed a more rigorous definition of approach than was used in Experiment 1, inasmuch as the tape-marked line delineating the approach area was moved to within 18 cm of the fine-mesh screen.

The second test was designed to assess whether self-maintenance behavior would increase in the presence of the imprinting stimulus. For present purposes self-maintenance behaviors included (a) preening and feather-ruffling, and (b) nibbling-type bill movements directed at the floor, walls, or screens of the apparatus. The test itself simply consisted of three 120-sec presentations of the moving stimulus occurring in single alternation with three 120-sec periods of stimulus withdrawal. On the assumption that unusually bright lights would induce some level of "anxiety" in the ducks (Eiserer, 1977) and thereby inhibit self-maintenance behavior, the two lights illuminating the subject compartment were changed from 7.5-W to 100-W bulbs. This procedure was followed in order to ensure a relatively low response baseline against which any facilitative effects of the imprinting stimulus might more easily be discerned.

The two supplementary tests were run at the rate of one per day, beginning two days following completion of Experiment 1.

Results and Discussion

Figure 2A shows the group mean seconds of approach to the moving stimulus, both in the presence of "fear" (i.e., during concurrent presentation of the novel stimulus) and in its absence. Approach was much greater under the fear condition, a difference that was reliable [$t(2) = 6.34$, $p < .05$].

Figure 2B shows the group mean seconds of self-maintenance behavior during both presence and absence of the imprinting stimulus. Although the difference between the two conditions did not reach significance [$t(2) = 2.44$, $p > .05$], self-maintenance behavior was greater in the presence of the stimulus than in its absence for each of the three birds, and no overlap occurred in the group ranges for the two stimulus conditions. The failure to find a statistically significant effect of stimulus presence can probably be attributed simply to the small number of subjects (N = 3) that were involved. Thus, the trend depicted in Figure 2B, together with the reliable effects found in the first supplementary test, is consistent with the notion that the nature of the attachment formed by the adult ducks was not substantially different from the imprinting attachments that are typically formed by newly hatched birds. While the possible confounding of Experiment 1 by sexual imprinting cannot be entirely eliminated, the present evidence that the imprinting object was a comforting stimulus strongly suggests the operation of a filial-type social bond. To be sure, the term

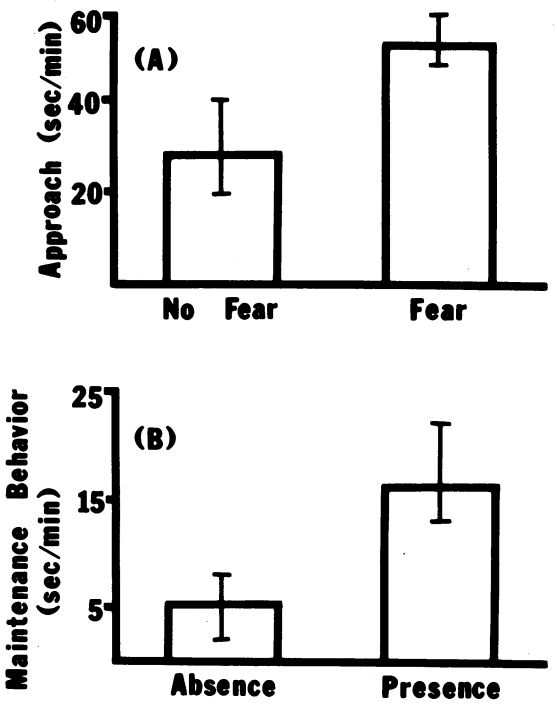

Fig. 2. (A) Group mean seconds of approach to the moving stimulus during the concurrent presence (fear) and absence (no fear) of a novel stimulus. Vertical lines depict ranges. (B) Group mean seconds of self-maintenance behavior during the presence and absence of the moving stimulus. Note the change in ordinate scale.

filial seems rather inappropriate with reference to adult subjects (perhaps *affiliative* would be a better word), but the important point is that the quality of the adults' relationship with the moving object appeared to be similar to the relationship that young ducklings would form during comparable exposure.

EXPERIMENT 3

One of the ducks in Experiment 1 (i.e., Duck 4) failed to respond to the moving stimulus, a finding that is not particularly surprising given the fact that even among newly hatched birds, some small percentage of animals do not imprint to laboratory objects under conditions that are sufficient for imprinting in the majority of subjects (Fischer, 1966, 1967). However, while such individual differences are perhaps to be expected, the question of why some birds fail to imprint must still be asked. At least three alternative explanations are possible here: either the nonimprinted birds merely need a greater amount of exposure than was needed by their fellows; or the employed laboratory object is simply qualitatively inadequate as an elicitor of filial behavior for the non-imprinted birds; or these birds, perhaps due to some subtle genetic defect, are completely incapable of forming normal imprinting attachments.

Experiment 3 sought to examine further the failure of Duck 4 to imprint to the moving stimulus. In doing so, the study provided the subject with substantial additional exposure to the moving stimulus to determine whether, with such treatment, Duck 4 would in fact imprint as had the other three adults.

Method and Results

After completion of the nine exposure sessions of Experiment 1, Duck 4 received 11 additional 30-min exposure sessions (and the accompanying approach tests) that were identical in procedure to the first nine. Intermittent observations during the exposure sessions revealed that at virtually no time did the subject enter the quadrant near the fine-mesh screen. Figure 3 shows the results from the 20 approach tests (i.e., including those that had been given to Duck 4 in Experiment 1), and as can be seen, the bird failed to approach even after 600 min of exposure to the moving stimulus.

Despite these results it seemed possible that Duck 4 had, nevertheless, developed at least some degree of attachment to the stimulus during the prolonged exposure, and that such attachment might become evident under conditions of fear. Therefore, on the day following the last exposure session, the bird was given the same test with the novel stimulus (i.e., the dangling paper cup) that the other three ducks had received in Experiment 2. Inset A of Figure 3, which shows the mean seconds of approach to the moving stimulus as a function of the presense (fear) and absence (no fear) of the novel stimulus, makes clear that concurrent presentation of the novel stimulus did not induce Duck 4 to approach the moving stimulus.

After completion of the novel stimulus test, Duck 4 was placed with the other three ducks in a single housing unit (127 by 127 by 61 cm) for a period of seven days. After that time Duck 4 was given an approach test with one of the other ducks serving as the test stimulus. For this test a clear Plexiglas partition was

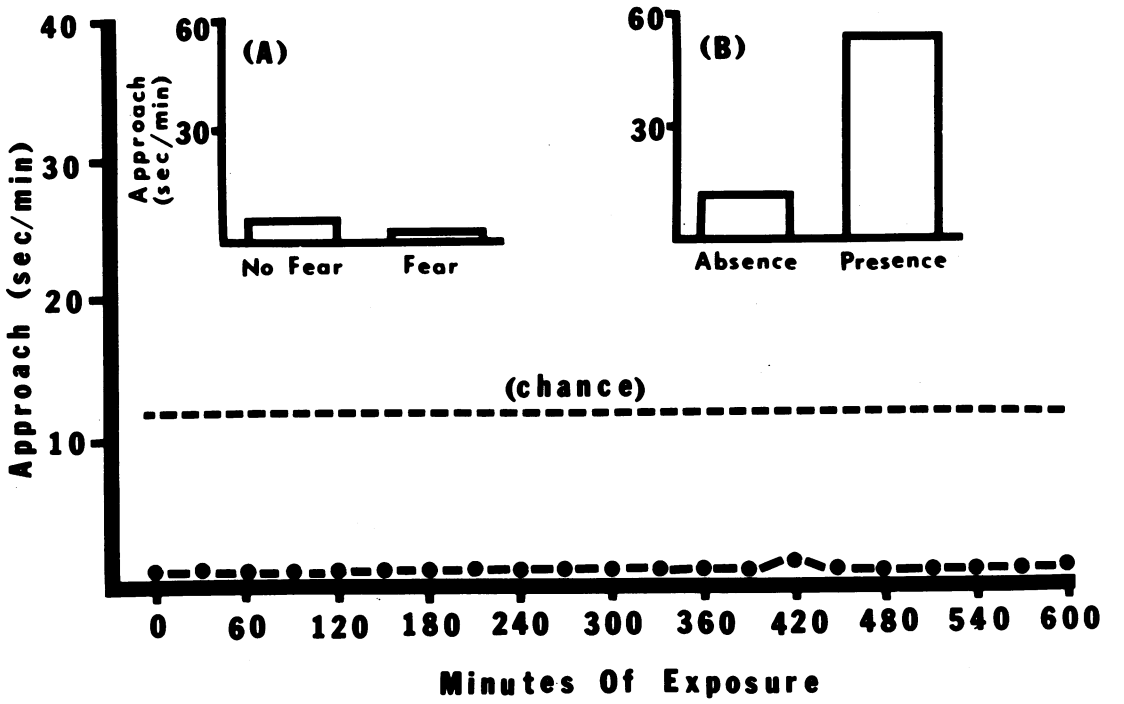

Fig. 3, Seconds of approach to the moving stimulus by Duck 4 as a function of exposure duration. *Inset A.* Mean seconds of approach to the moving stimulus by Duck 4 during the concurrent presence (fear) and absense (no fear) of a novel stimulus. *Inset B.* Mean seconds of entering the approach quadrant by Duck 4, during both the presence and the absence of a conspecific in the stimulus compartment.

placed across the width of the subject compartment of the experimental apparatus. The partition—which was constructed such that a second, opaque panel could readily be superimposed over the clear Plexiglas—divided the compartment into two unequal areas (Section A which was 36 by 66 cm, and Section B which was 106 by 66 cm). Section A served as the new "stimulus compartment" in which could be placed one of the three ducks with whom Duck 4 had been housed. Within Section B a strip of adhesive tape on the floor ran parallel to and at a distance of 21 cm from the Plexiglas partition, and thus delineated an approach area that was approximately 20% of the entire section.

At the beginning of the approach test, Duck 4 was placed in Section B, one of the other three ducks was placed in Section A, and the opaque panel was lowered so that the two birds could not see each other (a condition of "stimulus absence" for Duck 4). After an interval of 120 sec, the opaque panel was alternately raised ("stimulus presence") and lowered at 120-sec intervals until a total of five stimulus presentations had been completed. Inset B of Figure 3 shows the mean seconds of approach averaged across the five periods of stimulus presence and stimulus absence, respectively. The difference between the two conditions was statistically significant [$t(4) = 4.26$, $p < .05$], indicating that the stimulation provided by a conspecific was sufficient to elicit reliable approach responses from Duck 4.

Discussion

In the present study Duck 4 showed no indication of attachment to the moving stimulus, even under conditions of fear, despite having received two to four times as much stimulus exposure as had been required for development of attachment in the other three ducks (refer to Figure 1). Although such a result might have suggested that Duck 4 was incapable of developing approach responses to social stimuli, this possibility was eliminated by the demonstration of strong approach behavior toward a conspecific.

The present study does not permit determination of whether the difference in effective-

ness of the moving stimulus vs. the conspecific was due to the nature of the two stimuli (the conspecific being more "natural"), the length of exposure (10 hr to the moving stimulus vs. 7 days to the conspecific), or the quality of exposure (physical contact being permitted with the conspecific but not with the moving stimulus). Nevertheless, the present findings do suggest that Duck 4, like the other three ducks, was capable of imprinting to a novel object after five months of social isolation. Whether the same capability could be demonstrated in chickens as well was investigated in Experiment 4.

EXPERIMENT 4

Method

Subjects, Apparatus, and Procedure

Five male White Leghorn chickens (*Gallus gallus*), hatched in visual isolation from eggs obtained from George F. Shaw, Inc., served. The chickens were housed under the same conditions as were the ducks in Experiment 1. The experimental apparatus was also unchanged from the first study.

Imprinting procedures, begun when the chickens were 5 months old, were identical to those employed in Experiment 1 except that 20 (rather than 9) 30-min exposure sessions were administered. An approach test was given following each session as well as immediately before the very first session, for a total of 21 tests.

Results

During the first few exposure sessions, all of the chickens showed avoidance responses toward the moving stimulus, although these responses did not appear to be as vigorous as the avoidance that had been initially displayed by the ducks. As with the ducks, avoidance behavior gradually waned as exposure continued; unlike the majority of the ducks, however, consistent approach responses did not emerge. Instead, the chickens' later behavior seemed generally more comparable to that of Duck 4—i.e., reflecting a sort of "indifference" toward the moving stimulus, rather than either avoidance or approach.

A notable exception to this air of indifference was provided by two of the roosters who frequently displayed aggressive behavior (outward flaring of the neck feathers coupled with an abrupt, sideways "charge" at the stimulus, as well as occasional jumps and pecks at the fine-mesh screen) during the first few minutes of each of the later sessions. This aggressive behavior usually disappeared (habituated) by the end of each exposure session, and occurred only very sporadically during the approach tests.

Figure 4 shows the approach time for each subject as a function of duration of exposure (for purposes of smoothing, the data for each bird were averaged across blocks of three tests). As can be seen from the figure, the chickens did not consistently enter the approach quadrant at more than the chance level even after 600 min of exposure to the moving stimulus. An analysis of variance (treatments-by-subjects design) failed to find a significant change in approach across the exposure period, $F(6,24) = 1.82$, $p > .05$.

On the possibility that the chickens would consistently approach the moving stimulus under the heightened motivational conditions of fear, the birds were given the same test with the novel stimulus that the ducks had received in Experiment 2. Observation of the chickens during presentations of the paper cup confirmed that the birds reacted to the novel stimulus with attempts at withdrawal. However, Inset A of Figure 4, which shows the group mean seconds of approach both in the presence and absence of the novel stimulus, reveals that virtually no approach occurred under either stimulus condition.

After completion of the novel stimulus test, the five roosters were placed together in a single housing unit in order to determine whether they would form social attachments to each other. Unfortunately, this procedure had to be soon abandoned because of the great aggressiveness displayed by some of the birds and the bloody injuries incurred by others.

Discussion

Despite receiving substantially more exposure to the moving stimulus than had the ducks in Experiment 1, none of the chickens displayed a consistent approach response, even during concurrent presentation of a fear-inducing novel object. Although both the observations of the experimenter and the data in

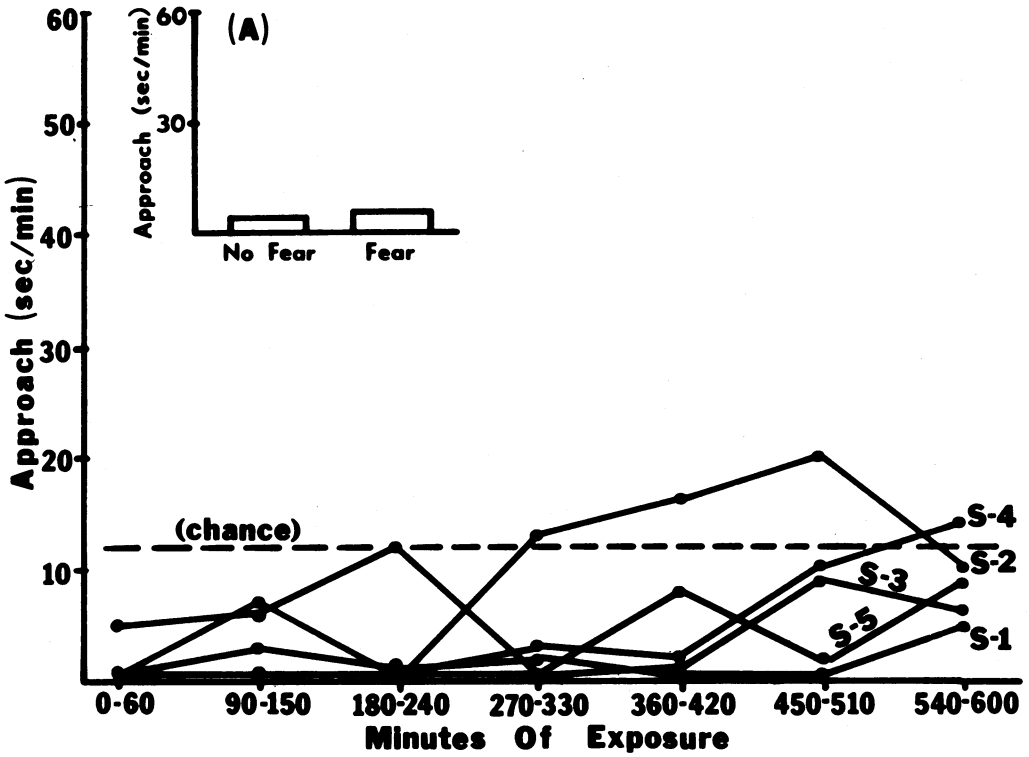

Fig. 4. Seconds of approach to the moving stimulus by the adult chickens (Subjects 1 through 5) as a function of exposure duration. The data for each bird have been averaged across blocks of three tests. *Inset A.* Group mean seconds of approach to the moving stimulus during the concurrent presence (fear) and absence (no fear) of a novel stimulus.

Figure 4 indicated that the chickens gradually stopped avoiding the moving stimulus (the approach responses eventually increasing to approximately the chance level), none of the five subjects showed the sort of filial behavior that had been evident in three of the ducks.

One possible explanation for the chickens' failure to imprint is that the moving lights provided stimulation that for some reason was inadequate for initiating the attachment process in this species. One test of this possibility —namely, exposing the chickens to the more natural stimulation provided by conspecifics— was hindered by the aggressiveness that emerged under conditions of group housing. However, another test might simply consist of determining whether newly hatched chicks would readily imprint to the moving lights. If not, then the failure of the adults could be attributed to characteristics of the stimulus rather than to limitations in the long-term attachment potential of the species.

Experiment 5 assessed this latter possibility by exposing newly hatched chicks to the moving stimulus. For purposes of comparison, a group of newly hatched ducklings was also included.

EXPERIMENT 5

Method

Subjects and Apparatus

Four Khaki Campbell ducklings and five White Leghorn chicks served as subjects. When not in the experimental apparatus, each bird was maintained in an individual cardboard box (31 by 51 by 31 cm) with continuous access to food and water.

The present study used the same imprinting apparatus that was employed in Experiments 1 through 4, except that the subject compartment was made smaller in length (84 by 66 by 78 cm) to accommodate the younger subjects. As in Experiments 1 and 4, the approach area represented 20% of the subject compartment,

with the adhesive tape forming a line along the floor 16.8 cm from the fine-mesh screen of the stimulus compartment.

Procedure

The ducklings and chicks were hatched and run several weeks apart from each other. In both cases the birds remained in the incubator until approximately 8 to 10 hr posthatch. At that time each subject began receiving a total of five 30-min exposure sessions with the moving stimulus at the rate of two sessions per day. Immediately following each of the sessions as well as immediately before the very first session, each bird received an approach test that was identical in procedure to the approach tests used in Experiment 1.

RESULTS AND DISCUSSION

Figure 5 shows approach time as a function of duration of exposure for each of the four ducklings and five chicks. Although, in general, both species failed to approach the moving stimulus during the first test, all four ducklings as well as four of the five chicks generated high approach scores by the third test. No avoidance responses were observed in any of the subjects at any time, and the low initial approach scores appeared instead to be largely due to the general physical weakness of the

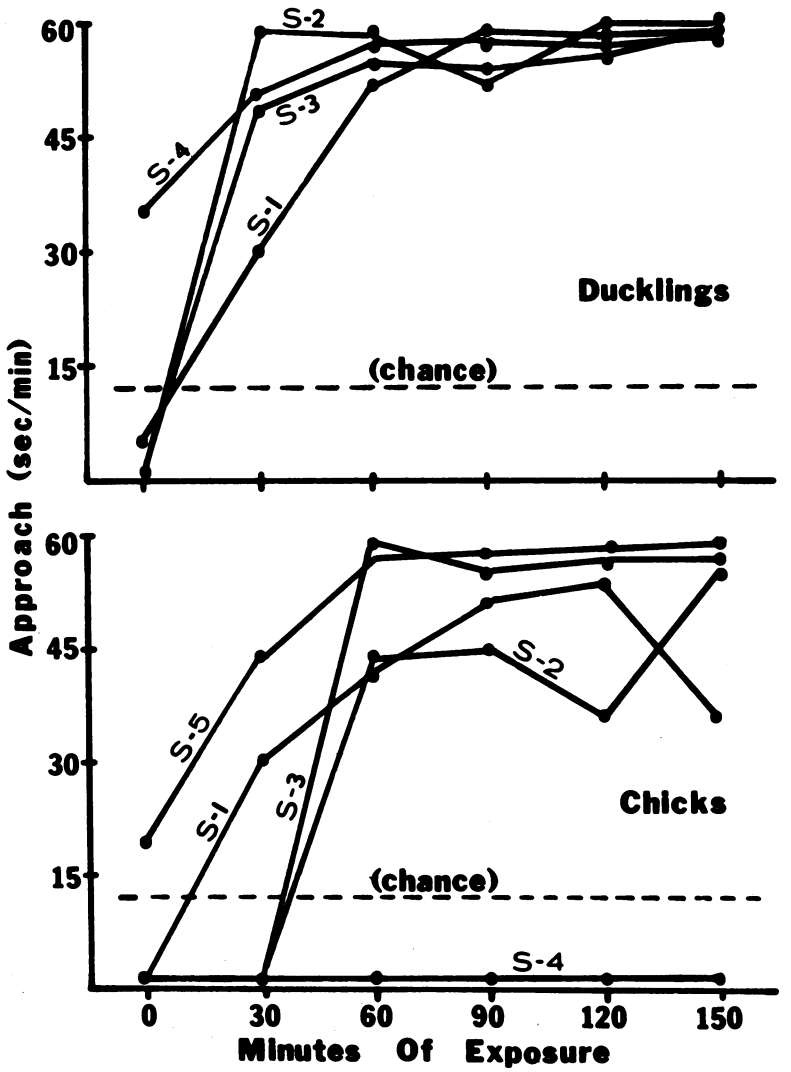

Fig. 5. Seconds of approach to the moving stimulus by each of four ducklings and five chicks as a function of exposure duration.

newly hatched birds. Hoffman, Stratton, Newby, and Barrett (1970) reported that newly hatched ducklings can show an immediate positive response to the initial presentation of a moving object, but those authors employed a nonlocomotor index of filial attachment (i.e., suppression of ongoing distress vocalization).

In any event, Figure 5 makes clear that the chicks (with the exception of Subject #4) as well as the ducklings were consistently approaching the moving stimulus after 60 min exposure to that stimulus. An analysis of variance yielded a significant effect of exposure, $F(5,35) = 21.94$, $p < .01$, but failed to find either a significant species difference, $F(1,7) = 2.72$, $p > .05$, or a significant interaction between the effects of exposure and species, $F(5,35) = 1.80$, $p > .05$.

GENERAL CONCLUSIONS

The present work indicates that 5-month-old ducks that have been isolated from hatch can still form social attachments to novel moving objects, and that such attachments are qualitatively similar to the filial bonds typically formed by newly hatched birds. Since the ducks had reached adulthood when the imprinting procedures were begun, it is unlikely that their attachment behavior would have been substantially different even if the initial isolation period had been extended beyond five months. Thus, at the admitted risk inherent in generalizing from one species (and from one sex), one could conclude that ducks in general never lose the capacity for imprinting.

Conclusions to be drawn for the chickens are less clear. Since none of the chickens imprinted to the moving lights after many more minutes of exposure than had been required by the ducks, there is little reason to think that even longer exposure would have had much additional effect. The ready imprinting to the stimulus by newly hatched chicks indicates that the moving lights were not inherently inadequate releasers of filial behavior in this species. Yet the cause of the difference in responsiveness between the chicks and the adults cannot be determined for certain from the present work.

One explanation is that present housing conditions permitted auditory exchange among the roosters, making it possible for mutual attachments to form. Under certain conditions old attachments can interfere with the development of new ones (Bateson, 1979; Eiserer & Hoffman, 1974), and perhaps the roosters' attachment to each other's vocalizations precluded a new attachment to the moving stimulus. Although the ducks were housed under identical conditions, adult Khaki Campbells may not generally be as responsive to social sounds as are adult chickens, whose vocal repertoire is much more extensive.

It is also possible that, if enforced visual exposure to conspecifics had been accomplished, the roosters would have developed true attachments to each other in a way similar to Duck #4. Some attachment response other than approach would have to be monitored, however, since approach might merely reflect the great aggressiveness of the chickens. Then, too, perhaps female chickens would have reacted to group housing with less aggression and more attachment than did the roosters.

In any event, the present work does offer preliminary evidence of a species difference between ducks and chickens in terms of the applicability of a limiting period for imprinting attachments. Such a period seems not to apply to ducks but may well apply to chickens, and one might be tempted to ask why. According to Immelmann (1975), "the duration of sensitive periods is adapted very accurately to the biology and the specific ecological demands of a species" (p. 24). However, the present findings on long-term imprintability need not imply that ducks and chickens differ markedly in the duration of their respective sensitive periods (i.e., the developmental period during which exposure to an imprinting object is most effective). Moreover, given that the primary manipulation in the present work (visual isolation from hatch to adulthood) can hardly occur in the natural circumstances of either ducks or chickens, it seems premature to speculate about possible adaptive values underlying the observed species differences. Of more immediate need is additional research to determine whether the apparent differences reported here for ducks and chickens hold up under different sets of experimental parameters.

REFERENCES

Andrew, R. J. The relation between the following response and precocious adult behaviour in the chick. *Animal Behaviour*, 1966, 14, 501-505.

Asdourian, D. Object attachment and the critical period. *Psychonomic Science,* 1967, **7,** 235-236.

Baer, D. M., & Gray, P. H. Imprinting to a different species without overt following. *Perceptual and Motor Skills,* 1960, **10,** 171-174.

Bateson, P. P. G. Changes in chicks' responses to novel moving objects over the sensitive period for imprinting. *Animal Behaviour,* 1964, **12,** 479-489.

Bateson, P. P. G. Imprinting and the development of preferences. In A. Ambrose (Ed.), *Stimulation in early infancy.* New York: Academic Press, 1969.

Bateson, P. P. G. How do sensitive periods arise and what are they for? *Animal Behaviour,* 1979, **27,** 470-486.

Bjarvall, A. The hatching and nest-exodus behavior of the Mallard. *Wildfowl,* 1968, **19,** 70-80.

Boyd, H., & Fabricius, E. Observations on the incidence of following of visual and auditory stimuli in naive mallard ducklings (*Anas platyrhynchos*). *Behaviour,* 1965, **25,** 1-15.

Brown, R. T. Following and visual imprinting in ducklings across a wide age range. *Developmental Psychobiology,* 1975, **8,** 27-33.

Case, V. J., & Graves, H. B. Functional versus other types of imprinting and sensitive periods in *Gallus* chicks. *Behavioral Biology,* 1978, **23,** 433-445.

Eiserer, L. A. Behavioral control by stimulus components of an imprinting object. *Animal Learning and Behavior,* 1977, **5,** 153-160.

Eiserer, L. A. Anomalous effects in psychology: Parallels between the brain stimulation and imprinting literatures. *Psychological Record,* 1978, **28,** 557-570. (a)

Eiserer, L. A. The effects of tactile stimulation on imprinting in ducklings after the sensitive period. *Animal Learning and Behavior,* 1978, **6,** 27-29. (b)

Eiserer, L. A., & Hoffman, H. S. Imprinting of ducklings to a second stimulus when a previously imprinted stimulus is occasionally presented. *Animal Learning and Behavior,* 1974, **2,** 123-125.

Fabricius, E. Crucial periods in the development of the following response in young nidifugous birds. *Zeitschrift für Tierpsychologie,* 1964, **21,** 326-337.

Fischer, G. J. Discrimination and successive spatial reversal learning in chicks that fail to imprint vs ones that imprint strongly. *Perceptual and Motor Skills,* 1966, **23,** 579-584.

Fischer, G. J. Hereditability in the following response of pedigreed white leghorns. *Psychonomic Bulletin,* 1967, **1,** 30.

Gaioni, S. J., Hoffman, H. S., DePaulo, P., & Stratton, V. N. Imprinting in older ducklings; Some tests of a reinforcement model. *Animal Learning and Behavior,* 1978, **6,** 19-26.

Gallagher, J. E. Sexual imprinting: A sensitive period in Japanese quail (*Coturnix coturnix japonica*). *Journal of Comparative and Physiological Psychology,* 1977, **91,** 72-78.

Gottlieb, G. Developmental age as a baseline for determination of the critical period in imprinting. *Journal of Comparative and Physiological Psychology,* 1961, **54,** 422-427.

Gottlieb, G. Following-response initiation in ducklings: Age and sensory stimulation. *Science,* 1963, **140,** 399-400.

Graves, H. B. Early social responses in Gallus: A functional analysis. *Science,* 1973, **182,** 937-939.

Guiton, P. Socialisation and imprinting in Brown Leghorn chicks. *Animal Behaviour,* 1959, **7,** 26-34.

Hess, E. H. Imprinting. *Science,* 1959, **130,** 133-141. (a)

Hess, E. H. Two conditions limiting critical age for imprinting. *Journal of Comparative and Physiological Psychology,* 1959, **52,** 515-518. (b)

Hess, E. H., & Schaefer, H. H. Innate behavior patterns as indications of the "critical period." *Zeitschrift für Tierpsychologie,* 1959, **16,** 155-160.

Hoffman, H. S., Ratner, A. M., Eiserer, L. A., & Grossman, D. J. Aggressive behavior of immature ducklings. *Journal of Comparative and Physiological Psychology,* 1974, **86,** 569-580.

Hoffman, H. S., Ratner, A. M., & Eiserer, L. A. Role of visual imprinting in the emergence of specific filial attachments in ducklings. *Journal of Comparative and Physiological Psychology,* 1972, **81,** 399-409.

Hoffman, H. S., Stratton, J. W., Newby, V., & Barrett, J. E. Development of behavioral control by an imprinting stimulus. *Journal of Comparative and Physiological Psychology,* 1970, **71,** 229-236.

Hoffman, H. S., Stratton, J. W., & Newby, V. The control of feeding behavior by an imprinted stimulus. *Journal of the Experimental Analysis of Behavior,* 1969, **12,** 847-860.

Immelmann, K. Sexual and other long-term aspects of imprinting in birds and other species. In D. S. Lehrman, R. A. Hinde, & E. Shaw (Eds.), *Advances in the study of behavior* (Vol. 4). New York: Academic Press, 1972.

Immelmann, K. Ecological significance of imprinting and early learning. *Annual Review of Ecology and Systematics,* 1975, **6,** 15-37.

James, W. *Principles of psychology.* New York: Holt, 1890.

Jaynes, J. Imprinting: The interaction of learned and innate behavior: II. The critical period. *Journal of Comparative and Physiological Psychology,* 1957, **50,** 6-10.

Lorenz, K. Der Kumpan in der Umwelt des Vogels. *Journal of Ornithology,* 1935, **83,** 137-213; 289-413.

Lorenz, K. The companion in the bird's world, *Auk,* 1937, **54,** 245-273.

McDonald, G. Imprinting: Drug-produced isolation and the sensitive period. *Nature (London),* 1968, **217,** 1158-1159.

Moltz, H., Rosenblum, L., & Halikas, N. Imprinting and level of anxiety. *Journal of Comparative and Physiological Psychology,* 1959, **52,** 240-244.

Moltz, H., & Stettner, L. J. The influence of patterned-light deprivation on the critical period for imprinting. *Journal of Comparative and Physiological Psychology,* 1961, **54,** 279-283.

Morgan, C. L. *Habit and instinct.* London: Edward Arnold, 1896.

Ramsay, A. O., & Hess, E. H. A laboratory approach to the study of imprinting. *Wilson Bulletin,* 1954, **66,** 196-206.

Ratner, A. M. Modification of ducklings' filial behavior by aversive stimulation. *Journal of Experimental Psychology: Animal Behavior Processes,* 1976, **2,** 266-284.

Ratner, A. M., & Hoffman, H. S. Evidence for a critical period for imprinting in Khaki Campbell ducklings (*Anas platyrhynchos domesticus*). *Animal Behaviour,* 1974, **22,** 249-255.

Sluckin, W., & Salzen, E. A. Imprinting and perceptual learning. *Quarterly Journal of Experimental Psychology,* 1961, **13,** 65-77.

Spalding, D. A. Instinct. With original observations on young animals. *Macmillan's Magazine,* 1873, **27,** 282-293.

Stettner, L. J., & Tilds, B. N. Effect of presence of an imprinted object on response of ducklings in an open field and when exposed to a fear stimulus. *Psychonomic Science,* 1966, **4,** 107-108.

Weidmann, U. Studies of Mallard behavior: Two experiments regarding the development and imprinting of following and flocking responses. *Zeitschrift für Tierpsychologie,* 1958, **15,** 277-300.

Williams, J. T. Developmental age and the critical period for imprinting. *Psychonomic Science,* 1972, **27,** 167-168.

Wilson, G. F. Early experience and facilitation of feeding in domestic chicks. *Journal of Comparative and Physiological Psychology,* 1968, **66,** 800-802.

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